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REVIEW OF EARTHQUAKES IN NIGERIA: AN UNDERSTUDIED AREA

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ABSTRACT

Nigeria in times past was believed to be aseismic. Nevertheless, the seismic record of Nigeria from 1933 till date have shown contrary to the belief. There have also been seismic warnings and forecasts from researchers concerning the seismicity of Nigeria in recent times. To this end, this paper carried out a critical review on the seismicity of Nigeria to further create awareness as earthquakes in Nigeria would be best classified as an area that has had less attention. This review was carried out by employing qualitative approach. The findings established Nigeria to be a low seismic country that is susceptible to a large earthquake in her south-west region in the nearest future. Hence, the government of Nigeria should pay attention to earthquakes in the south-west region of Nigeria to safeguard lives and properties against the future probable quakes.

Key words: Earthquakes, Forecasts, Magnitude, Seismic and Tremor.

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1. INTRODUCTION

Natural disasters are events that happen unexpectedly in nature. The occurrences of these disasters have been as far as man can remember, the beginning of his existence on the planet earth. Among the several natural disasters experienced on earth, earthquake is regarded as one of the greatest disasters that occur with capabilities to leave human lives and properties hazarded based on how large it is in magnitude. The continuous occurrence of earthquake in different parts of the world has continued to be a source of concern to man, and experts have continued to research tirelessly to find ways to mitigate the aftermath such as damages and loss incurred from its occurrence [1]. According to [2], earthquakes occur as shakings. Most

of the shakings experienced on the surface of the earth are either earthquakes or tremors. Though both are usually unknowingly referred to as earthquakes, the shakings with high magnitude and with serious damage are known as earthquakes while the shakings with small magnitude are referred to as tremors. Tremors usually occur in a region as a sign that earthquake of larger magnitude is likely to occur.

Seismic hazard is a source of major threat to mankind. Seismic hazards have the ability to cause notable and serious destructions and damages to biodiversity and man's immediate environment. The effect of the resulting damage is not only limited to the moment of occurrence but also impacts negatively years after. Damages from impacts of natural hazards leave trail on vital infrastructures, properties, and even human lives. Earthquakes of large intensities and magnitude can also have adverse effect on the economy of the affected Community such that it can take years for the region to regain her economic status [3,4,5,6,7,8].

Earthquake occurrence is a global phenomenon. While some countries have high seismicity, some others are with low seismicity and some are free from seismic events. Among the nations of the earth, Nigeria is one of the countries that have reflected light and dispersed seismic events in her seismic record so far. Though the events in her record are of small to medium magnitude, there have also been on record medium-large magnitude. It is believed that Nigeria has her geological framework founded within the Africa's mobile belt which is located between the Congo Craton and West Africa Craton.

Notable damage and deformation were reported to have taken place within the belt in the past and has had a bit of effect on the adjacent craton. This referred to the Pan-African orogeny which happened 600 ± 100Ma and was recorded to be the last of its kind. This is likely to be the explanation as to why Nigeria hardly experience earthquake [9].

It used to be an established belief that the country Nigeria is totally free from seismic hazard due to the fact that seismic hazards were not in her records at the time of the belief. Nevertheless, seismic hazard occurrences in the past years have proven this belief to be untrue. Most of the seismic hazards such as tremors that had taken place in Nigeria in previous years were not recorded by seismic instruments because adequate equipment for recording such was not available in Nigeria at the times of the occurrences. Quakes and tremors have ever since been recorded in Nigeria. In taking cognizance of seismic activities in Nigeria, any possible future occurrence of earthquake is said to likely to occur along the faults in Nigeria. Recent developments have also shown that West Africa and Nigeria are likely to face devastating earthquake occurrences in times to come [10,11].

1.1. Earthquakes in Nigeria

Many earthquakes and tremors have been recorded in Nigeria over the years. These quakes are dispersedly distributed through the geopolitical zones in Nigeria. Nigeria as a country has six geopolitical zones namely the North-Central Zone (NC), North-East Zone (NE), North-West Zone (NW), South-East Zone (SE), South-South Zone (SS) and the South-West Zone (SW). A good breakdown of the six geopolitical zones in Nigeria is related by [12] as follows:

- North Central (loosely known as Middle Belt): Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, Abuja
- North East: Adamawa, Bauchi, Borno, Gombe, Taraba, Yobe
- North West: Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, Zamfara
- South East: Abia, Anambra, Ebonyi, Enugu, Imo

- South South: Akwa Ibom, Cross River, Bayelsa, Rivers, Delta, Edo
- South West: Ekiti, Lagos, Ogun, Ondo, Osun, Oyo.

The first quake ever in Nigeria occurred in 1939 in Ibadan, and the first tremor was recorded in Warri in 1933. Many other earthquakes have occurred after this. Recently on the 11th of September 2009 around 03:10:30am in Abeokuta, a quake with an intensity of VII and a magnitude of 4.8 was recorded. Researchers from National Space Research and Development Agency (NARSDA) by corroboration on the incidence ascertained that Nigeria is not a country that is free from earthquake hazard and focus have ever since been on the built environment in the nation [13]. Some instrumental and historically recorded earthquakes in Nigeria from the year 1933 to 2016 as extracted from [9,14], is presented in the Table 1. Some of these earthquakes were recorded using the earthquake local magnitude scale and some were recorded using the Modified Mercalli Intensity scale.

Table 1 History of Earthquake Events in Nigeria

S/N	Year-Month-Day	Origin Time	Felt Areas	Intensity/ Magnitude	Probable Epicenter	Coordinates	
1	1933	-	Warri	-	-	05º 45¹ 23¹¹E	05º 31¹ 42¹¹N
2	1939-06-22	19:19:26	Lagos, Ibadan, Ile-Ife	6.5 (Ml)	Akwapin fault in Ghana	03º 23¹ 00¹¹E	06º 30¹ 11¹¹N
3	1948-07-28	-	Ibadan	-	Close to Ibadan	-	-
4	1961-07-02	15:42	Ohafia	-	Close to ijebu-Ode	-	-
5	1963-12-21	18:30	Ijebu-Ode	V	Close to Ijebu-Ode	-	-
6	1981-04-23	12:00	Kundunu	III	At Kundunu Village	-	-
7	1982-10-16	-	Jalingo, Gembu	III	Close to Cameroun Volcanic Line	-	-
8	1984-07-28	12:10	Ijebu-Ode, Ibadan, Shagamu, Abeokuta	VI	Close to Ijebu Ode	-	-
9	1984-07-12		Ijebu Remo	IV	Close to Ijebu Ode	03º 23¹ 00¹¹E	07º 11¹ 45¹¹N
10	1984-08-02	10:20	Ijebu-Ode, Ibadan, Shagamu, Abeokuta	V	Close to Ijebu Ode	-	-
11	1984-12-08	-	Yola	III	Close to Cameroun Volcanic Line	-	-
12	1985-06-18	21:00	Kombani Yaya	IV	Kombani Yaya	-	-
13	1986-07-15	10:45	Obi	III	Close to Obi town	08º 46¹E	08º 22¹N
14	1987-01-27	-	Gembu	V	Close to Cameroun Volcanic Line	11º 15¹E	06º 42¹N
15	1987-03-19	-	Akko	IV	Close to Akko	10º 57¹E	10º 17¹N
16	1987-05-24	-	Kurba	III	Close to Kurba village	10º 12¹E	11º 29¹N

17	1988-05-14	12:17	Lagos	V	Close to Lagos	-	-
18	1990-06-27	-	Ibadan	3.7(ML)	Close to Ijebu-Ode	03º 58¹E	17º 22¹N
19	1990-04-05	-	Jerre	V	Close to Jerre Village	-	-
20	1994-11-07	05:07:51	Ojebu-Ode	4.2(ML)	Dan Gulbi	-	-
21	1997	-	Okitipupa	IV	Close to Okitipupa Ridge	-	-
22	2000	-	Edo	4.5	Siluko, Edo		
23	2000-08-15	-	Jushi-Kwari	III	Close to Jushi Kwari village	07º 42¹E	14º 03¹N
24	2000-03-13	-	Benin	IV	Benin City (55km from Benin)	-	-
25	2000-03-07	15:53:54	Ibadan, Akure, Abeokuta, Ijebu-Ode, Oyo	4.7 (ML)	Close to Okitipupa	-	-
26	2000-05-07	11:00	Akure	IV	Close to Okitipupa Ridge	-	-
27	2001-05-19	-	Lagos	IV	Close to Lagos city	-	-
28	2002-08-08	-	Lagos	IV	Lagos city	-	-
29	2005-03	-	Yola	III	Close to Cameroun Volcanic Line	-	-
30	2006-03-25	11:20	Lupma	III	Close to Ifewara	-	-
31	2009-09-11	-	Abomey-Calavi	II	Close to Benin	-	-
32	2011-11-05	-	Abeokuta	4.4	Close to Abeokuta	-	-
33	2016-07-10	-	Saki	IV	Oyo State	-	-
34	2016-08-10	-	Igbogene	III	Bayelsa	-	-
35	2016-09-11	-	Kwoi	III	Kaduna State	-	-
36	2016-09-12	-	Sambang Dagi	III	Kaduna	-	-

Sources: [9,14]

The southwest region of Nigeria has been experiencing more earthquakes among other geo-political zones in Nigeria. This is a pointer to the fact that this zone is prone to earthquake among other zones in Nigeria. The government of Nigeria was recently called to attention by The Nigerian Association of Water-Well Drilling Rig Owners and Practitioners (AWDROP) for measures that are capable of limiting or reducing the effects of earthquake aftermath. AWDROP called the Nigerian Government to pay attention to the prediction that earthquake of large magnitude is likely to occur in Shaki located in the southwest region of Nigeria. The earthquake was predicted by some researchers and led by Dr. Adepelumi Adekunle Abraham, of the Department of Geology, Obafemi Awolowo University, Ile Ife. Their report was titled 'Preliminary Assessment of Earth Tremor Occurrence in Shaki Area, Shaki West Local Government, Oyo State, indicating an impending danger. The head of AWDROP also stated to the government that the lack of regulation towards underground water extraction can be a

source of induced earthquake, therefore there should be a strict compliance in the code of practice implementation [15].

1.2. Geological Setting of Nigeria

In Nigeria, about half (50 %) of the total surface area falls under the basement complex. The major compositions of her lithosphere are mainly the metavolcanic rocks, the metasedimentary rocks, and the migmatite rocks. The lithospheric component of the northern and the southern part of Nigeria has been known for several years to be majorly characterized by the migmatite gnesis rock and this has continued to encroach beyond its boundaries. Hence, the basement in these two regions are referred to as "sensu stricto". In an attempt to point out the clear difference between the granitiods of pan Africa and the peralkaline of Jurassic, Falconer in 1911 stepped into the light to clarify this by using the morphological and the textural basis to establish the difference [16].

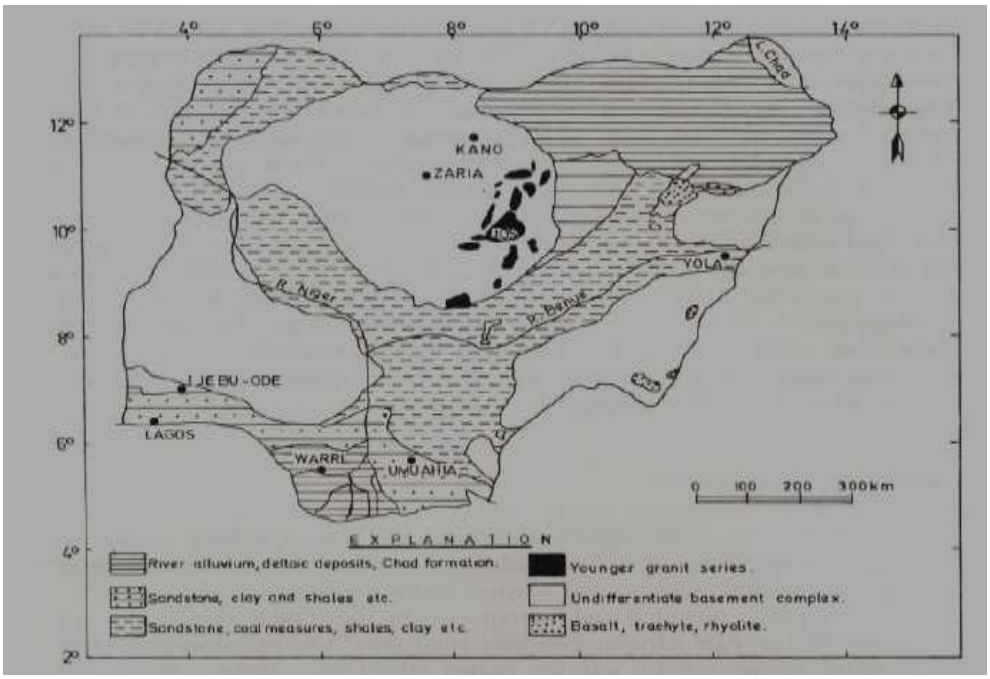

Figure 1 Geological Map of Nigeria Source: [17]

Falconer used the term "younger granites" for the peralkaline while the term "older granites" was adopted for the granitiods. A simplified geological map of Nigeria is related in the Figure 1.

The major rocks of the granitiods was found to be mainly granites which was a major intrusion beyond other rocks that was in existence before it. The migmatite gnesis rock is one of such rocks. Example of places where the granitic lithosphere can be located in Nigeria includes the presidential villa in Abuja (Aso Rock), Olumo Rock in Abeokuta, Ikere hills in Cross Rivers state and many other places. While the locations of the granitic rocks in Nigeria also contain other rocks, the granitic rocks have proven to predominantly constitute the areas. Some of the other rocks are usually found in the granitic lithosphere are the paragnesses, migmatites, metamorphosed rocks and orthogenesis. The analytical composition of the granitic lithosphere also revealed the heavy presence of granordites, adamallite, tonalite, diorite, non-porphyrites and porphyrites [16].

1.3. Seismic Faults in Nigeria

Some geophysical studies have established that there is the existence of an active seismic fault in Nigeria. The fault was named the Ifewara-Zungeru fault due to the bearing of the line of the fault as it trends through the Ifewara zone of south-western Nigeria. This is the thick black line represented in the Nigerian map of Figure 2. The Figure 3 also presents other possible line of faults in Nigeria.

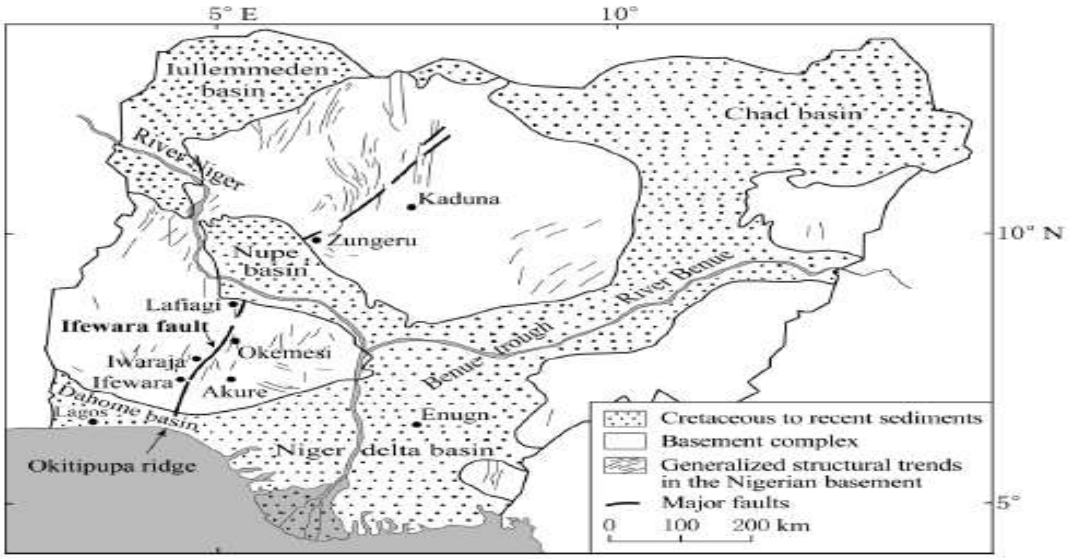

Figure 2 The Ifewara-Zungeru fault on the Nigerian Map (Sources: [9]

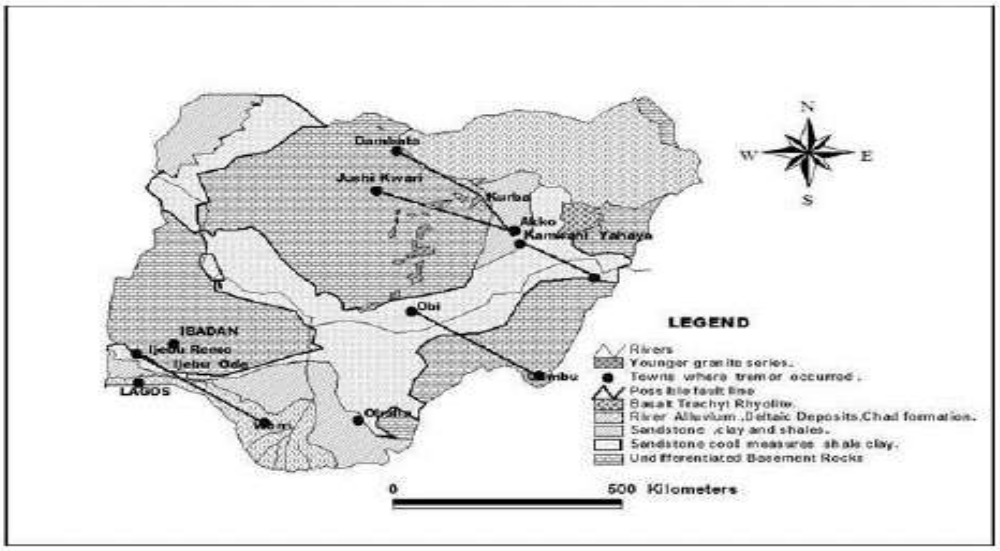

Figure 3 Possible Fault Lines in Nigeria Source: [9]

The Ifewara zone in the south west region of Nigeria also laps with the Schist belt in the complex of Nigerian basement. Although the Ifewara-Zungeru fault is already established to be active in Nigeria, other possible faults may also exist due to the dispersed seismic activities in the country. Some of the other possible faults in Nigeria are the Anka fault, Jushi Kwari-Akko fault, Dambata-Akko fault, Kalangai fault and others. It is believed that subsequent earthquakes in Nigeria will occur along the existing lines of fault [18].

1.4. Probable Reasons of Earthquake Occurrence in Nigeria

Although Nigeria in previous years was debated to be seismically free, several quakes have been witnessed till recent times. Hence, Nigeria is not certified safe from seismic activities. While there are active seismic countries such as China and Japan, Nigeria cannot yet be regarded to fall into this category. To this end, researchers have tried to establish a basis for the earthquake occurrences in Nigeria. It was gathered that the reason why Nigeria experience earthquake is likely to be as a result of stresses generated between the African plate and southern American plate which is likely to exact pressure on the coastal area of Nigeria that lies within this boundary. According to [18], stresses that are induced by the movements of the African plate and the southern American plate could be possibly translated to that of Nigeria and lead to the occurrences of earth tremors in the faults. According to some other beliefs, the geological location of Nigeria is the representation of the Figure 4.

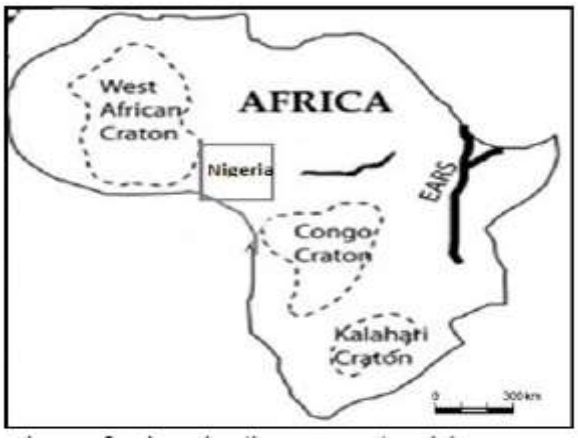

Figure 4 The Geological framework of Nigeria Source: [9]

It is believed that the stress induced on the plates of Nigeria due to the orogeny deformations that occurred along the cratons years ago could also be the reasons for the tremors being experienced in Nigeria [19].

1.5. Seismic Stations in Nigeria

Subsequent occurrence of earth tremors in Nigeria has been a major surprise to most Nigerians of late as West Africa is always considered to be located in a safe seismic zone and is regarded as a stable area. Millions of earthquakes with varying sizes are said to take place globally every year. These range from tremors of minor sizes which only a sensitive recording instrument has the capacity to detect and also large tremors that have the capabilities to cause appreciable impact on human lives and damage to infrastructure. World-wide distribution of earthquake is a good indication of seismicity of regions in the world. Orogenic activities such as earthquakes and volcanism are bound to the plate boundaries of the lithosphere according to the theory of plate tectonics though occurrences of intraplate earthquakes have been seen on record. Despite the fact that West Africa is situated far from the plate boundaries, devastating earthquakes have occurred in some of her regions. Lack of good disposition towards data collection of earthquakes in Nigeria which has tarried for a long time has created a major gap in the seismic data records of Nigeria.

Although many tremors have been recorded in Nigeria as far as taking the record from the 1933 to recent times, many tremors have also gone undetected with recording instruments. Most of the undocumented events were said to have taken place when the country had no technology to take the record of seismic events [17].

A gradual approach to improve the seismic record of Nigeria has currently brought the country to a status of having five active seismic stations in Nigeria. Nevertheless, the Nation plans to increase the number of seismic stations dispersed across the country. The Centre for Geodesy and Geodynamics (CGG) Toro is saddled with the task of monitoring and studying seismic events of the country. The currently active seismic stations have 24-bit 4- channel data acquisition system with seismometers broadband. It is said that telemetry equipment will soon be included in the features of the stations. Table 2 and Figure 5 shows the active stations that are currently managed by the Centre and more proposed stations are also included.

Table 2 Locations of Current and Proposed Seismic Stations in Nigeria

N/S	Station code	Name	Geological Foundation	Instruments installed	Coordinates
1	Oyo	Oyo	Granite	SP-400 Seismometer, DR4000	07° 53¹131¹¹N, 03°57¹078¹¹E
2	IBN	Ibadan	Gneiss	No Instrument Installed	07°27¹251¹¹N, 03°53¹520¹¹E
3	IFE	Ile - Ife	Gneiss	EP-105, Broadband Seismometers, DR4000 Recorder	07°32¹800¹¹N, 04° 32¹815¹¹E.
4	AWK	Awka	Shale and Silt stone	EP-105, Broadband Seismometers, DR4000 Recorder	06° 14¹561¹¹N, 07° 06¹ 693¹¹E
5	NSU	Nsukka	Sandstone	EP-105 Broadband Seismometer, DR4000 Recorder	06° 52¹011¹¹N, 07° 25¹045¹¹E
6	ABK	Abakaliki	Sandstone	EP-105 Broadband Seismometer, DR4000 Recorder	06°23¹453¹¹N, 08° 01¹474¹¹E
7	ABJ	Abuja	Granite	No Instrument Installed	08°59¹126¹¹N, 07°23¹380¹¹E
8	TOR	Toro (Central)	Gneiss	EP-105 Broadband Seismometers, DR4000 Recorder	10°.26¹303¹¹N, 09° 07¹089¹¹E
9	KAD	Kaduna	Granite	EP-105 Broadband Seismometers, DR4000 Recorder	10° 26¹101¹¹N, 07° 38¹484¹¹E
10	MINN	Minna	Granite Gneiss	EP-105 Broadband Seismometer, DR4000 Recorder	09° 30¹702¹¹N, 06° 26¹411¹¹E

Source: [9]

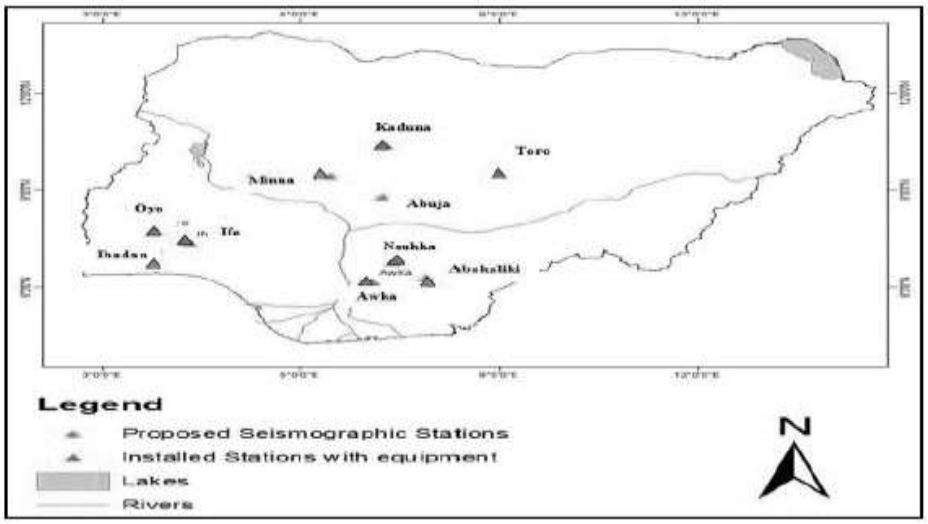

Figure 5 The Existing and proposed Seismic Stations in Nigeria Source: [20]

1.5. Earthquake Forecast in Nigeria

Nigeria has had in recent years several seismic alerts and warnings from agencies and researchers in Nigeria. The few precise ones in this regard are the forecasts of [18], [21,22]. The forecast of [18] established that an earthquake of ≥ 5.0 magnitude is likely going to be witnessed in the south-western part of Nigeria between the year 2010 and 2028. The forecast had a probability that increased from 6% to 91.1% between 2010 and 2028. To this end, [21,22] researched to bridge the gap identified as gap in knowledge as regards the extent of probable future earthquake in Nigeria. The research established Nigeria as a country with low seismicity with the extent of future earthquake that is as high as 7.2 in her south-west region. It is certainly possible to argue out the fact that Nigeria, a region with low seismicity can never experience an earthquake of such magnitude. Nevertheless, Antarctica according to [23], a region certified to be with least seismicity in the world experienced an earthquake of 8.1 magnitude in 1998. Hence Nigeria despite being a low seismic country can experience earthquakes as forecasted by the researchers.

2. METHODS

The review process contained in this work employed a qualitative approach. Several internet sources and related publications were used to establish this review.

3. FINDINGS

As against the belief of many that Nigeria is a country that is free from seismic occurrences, Nigeria is rather a low seismic country based on seismic parameter (a-value) established to be 16.8 by [22]. Nigeria is also at a future risk of experiencing a probable quake that is up to 7.2 Ml in her south-west region.

4. CONCLUSIONS

Based on the forecasts of researchers, Nigeria is susceptible to large probable future earthquake in her south-west region and her seismicity is best classified as low.

5. RECOMMENDATION

It is recommended that the government of Nigeria pay rapt attention to the forecasts of researchers especially in the south-west region to safeguard lives and properties against the future forecasts.

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